Self-Changing of Animal Hearing to Mitigate the Effects of Loud Sound

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LONG-TERM GOALS

Work on the hearing of animals while they echolocate (Supin et al, 2008: Nachtigall et al 2008) has demonstrated that hearing sensitivity changes with echolocation condition. False killer whales, bottlenose dolphins (Li et al, 2012) and harbor porpoises (Linnenschmidt et al, 2012) maximize hearing of echoes and minimize sensitivity to loud outgoing clicks. These observations led to the idea that perhaps these animals might also change hearing sensitivity out side of the echolocation situation. Perhaps they might protect their own hearing by reducing sensitivity if they were warned to a loud impulsive sound was about to arrive. The long term goal of this work is to examine whether or not cetaceans will change their hearing sensitivity when warned that a loud impulsive sound is about to immediately arrive.

OBJECTIVES

The objective of this work is to find out whether odontocetes change their hearing sensitivity if a neutral tone is presented just prior to a loud impulsive sound. If the animals do change their sensitivity the further objective is to measure the amount of hearing sensitivity change.

APPROACH

A false killer whale will be trained to sit in a hoop wearing soft suction cups containing skin surface electrodes that can measure hearing sensitivity via evoked auditory potentials (e.g. Supin et al 2003).

Hearing sensitivity threshold levels are established by playing a warning sound at various low levels and establishing at which level the animal can just barely hear the sound. That warning sound is then paired with a loud 170 dB sound and the animal's sensitivity thresholds are remeasured to see whether it has quickly learned to change its hearing sensitivity because a loud sound is about to arrive.

WORK COMPLETED

One set of experiments has been completed with the false killer whale. A second set of experiments is planned in the last month of this effort using both the bottlenosed dolphin and the false killer whale.

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RESULTS

Hearing sensitivity was measured using auditory evoked potentials (AEP). The whale had been trained to station within a hoop while wearing surface electrodes. Baseline AEP dependence on test-sound level and an auditory threshold were first established for a 20 kHz tone. Faint test stimuli were used, from 80 to 120 dB re 1 µPa. In a second phase, the test sound was followed by a sudden increase in amplitude up to 170 dB re 1 µPa. Thus, the faint test sounds took on the role of a conditioning signal that warned of the ensuing loud (unconditioned) sound. After a few trials, the test stimuli revealed a substantial reduction of hearing sensitivity *before* the loud sound. If the delay between the warning tone onset and loud tone was short (varied randomly from 1 to 9 s), the whale increased its hearing thresholds (reduced sensitivity) by around 15 dB (Fig. 1). Interestingly, when the delay was longer (varied from 20 to 140 s), the shift of sensitivity was negligible. Any unconditioned effect should have been the same irrespective of the relation between conditioning and loud sounds. Thus, the data indicate that: (1) the whale learned to change hearing sensitivity when warned that the loud sound was about to arrive; and (2) the learning acted only when warnings were immediate.

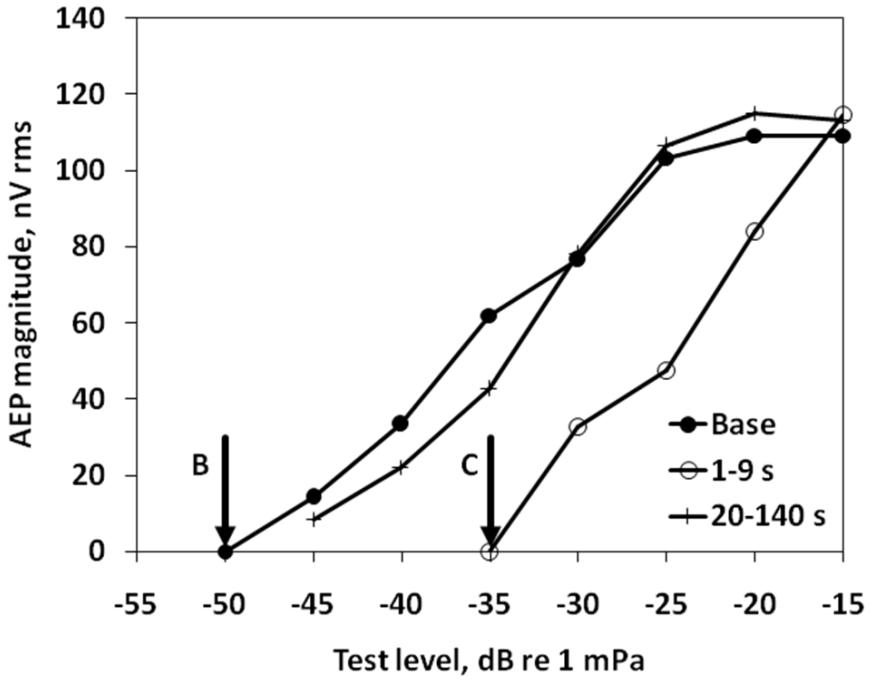

Figure 1. Auditory evoked potential (AEP) root-mean-square (rms) magnitude (ordinate) as a function of test sound level (abscissa). Base – baseline (no loud tone), 1-9 s and 20-140 s – loud tone delayed 1 to 9 and 20 to 140 s, respectively. Arrows mark baseline threshold (B) and conditioned threshold (C), respectively.

IMPACT/APPLICATIONS

This sensitivity change suggests that a neutral signal just before the introduction of loud anthropogenic sounds like sonar or airgun pulses may be a way to condition wild animals to self-mitigate the effects of loud sounds. Presumably the animals will learn to reduce hearing sensitivity, reinforced by the

avoidance of negative effects of loud sounds (Bolles &Seelbach, 1964) as has long been shown as a very basic learning process.

TRANSITIONS

It would seem a bit early to be discussing transitions, but if this work verifies the initial findings and is validated by work with other species, it would seem reasonable that this effort would transition into a major new effort to mitigate the effects of impulsive sound on marine mammals. Warning signals before functional sonar signals would allow wild animals to protect and change their hearing by 15 dB or more, depending on future findings.

RELATED PROJECTS

Title: Marine Mammal Hearing and Echolocation
Source: Office of Naval Research N000-8-1160
Identity of Prime Offerer: Office of Naval Research
Technical Contact: Dr. Michael J. Weise, Marine Mammals & Biological Oceanography Program, Office of Naval Research - Code 32, One Liberty Center - Rm 1068, 875 N. Randolph St., Arlington, VA 22203-1995, 703.696.4533 (office), 703.696.2007 (fax), michael.j.weise@navy.mil
Relation to proposed effort: This work provided the basis for the development of ideas upon which the current proposal is based

Title: Self changing of animal hearing to mitigate the effects of loud sound
Source: Exxon Corporation
Identity of Prime Offerer: Exxon Corporation
Technical Contact: Dr. Gary H. Isaksen Exxon Mobil Exploration Company E&P Sound and Marine Life, Project Manager External Technology Collaboration, Manager 233 Benmar, CORP-GP3-484A P.O. Box 4778, Houston, TX, 77210 Office: 281 654 7562; Cell: 713 254 0052; Fax: 1-281-654-7780 E-Mail: gary.h.isaksen@exxonmobil.com
Relation to proposed effort: This is essentially a start-up to get the project going. It is recognized as insufficient to complete the work.

Title: Ruggedized Portable Instrumentation Package for Marine Mammal Evoked Potential Hearing Measurements
Source: U.S. Department of Defense, Office of Naval Research
Identity of Prime Offerer: Office of Naval Research
Much of the equipment used on the reported project was developed on this project.

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PATENTS

Provisional Patent. Dolphin and Whale Hearing Protection. U.S. Patent Application Ser. No. 61/622,461. Patent Pending.